Reference Concentration in Shelf Sediment Transport

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LONG-TERM GOALS

My long-term goal is to understand the processes that contribute to the establishment of the vertical structure of the size-distribution of suspended sediments and sediment concentration, with the bottom boundary layer acting as the principal source.

OBJECTIVES

In the present experiment, the focus is on understanding the processes that establish the concentration and size-distribution of sediments at a small distance above the seabed. This concentration is termed the reference concentration, and it remains the most difficult to characterize for modeling.

APPROACH

We are attempting the full sediment characterization in a shallow water bottom boundary layer (BBL). Our suite of instruments includes current measurements and bedform characterization (to be done by co-investigator Dr. Cacchione at the Woods Hole Group, Menlo Park,CA), and the vertical size-distribution and concentration characterization using our LISST series instruments. In particular, a LISST-100 size-distribution measuring instrument shall be placed at 1.8m above bed on a tripod. At 0.8m above bed, a LISST-ST instrument shall be placed to determine the settling velocity distribution. Finally, the central measurement of the reference concentration shall be made by a specially configured sensor system MSCAT (Miniature SCattering And Transmissometer). The last instrument makes measurements of the concentration and size distribution at small distances above the seabed.

WORK COMPLETED

During the first year of this program (FY2001), we hare preparing the instruments for field deployment. An opportunity for field testing the suite of instruments existed at the LEO-15 site where the PI has a research program funded by ONR.

As a consequence, we now have gathered data on the *size-distribution*, *concentration*, and *settling velocity distribution* of suspended particles, measured both throughout the water column, and more extensively in the bottom 2 meters, from a tripod .

RESULTS

Settling Velocities of Suspended Particles: We have published the measurements of settling velocities of suspended particles earlier (Agrawal & Pottsmith, 2000). A particularly successful experiment at the LEO-15 site, in the context of the ONR-funded HYCODE program reveals significant variability in settling velocites on a day to day basis. For example, we show below settling velocity estimates from two experiments conducted covering 5 consecutive days.

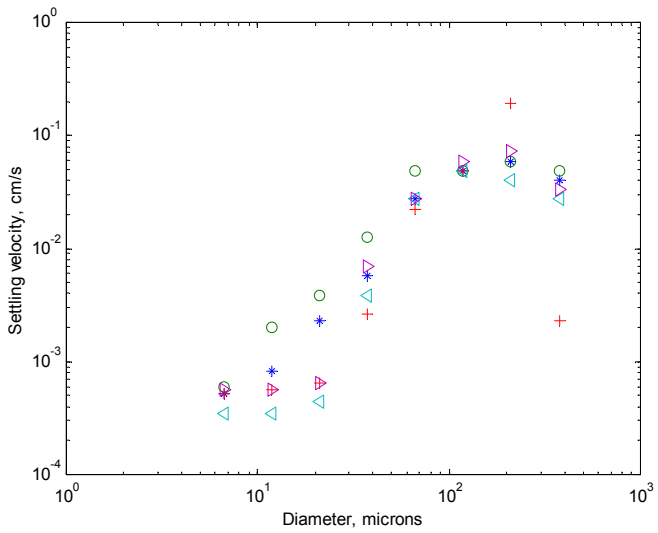

Figure 1. Settling velocity spectra for 5 settling experiments on successive days. Note that the estimates of settling velocity are within a narrow range for the 'floc size' range from 70-350 microns, and that there appears to be a consistent decreasing trende in settling velocity for the two largest size classes.

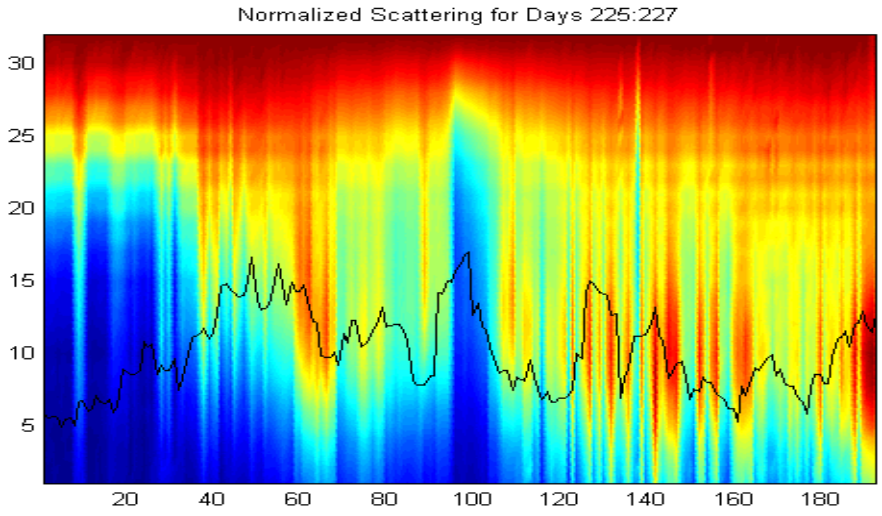

***Figure 2**: Normalized multi-angle scattering; days 225-227, CY2000. The abscissa is sample no., taken 15 minutes apart; the ordinate is the LISST ring-detector no.(or log of scattering angle). Reds mean high intensity scattering. Note the intrusions of high intensity peaks at smaller angles at samples 60, and between 120-200. These imply the presence of larger size particles. The black line is the normalization factor.*

Finally, we show some relevant data that is obtained in an unfunded related program. These data concern the small-angle scattering properties of natural particles, that is, non-spheres. The importance of this work is in the interpretation of multi-angle scattering from ensembles, as is done by the LISST instruments. Current practice in using multi-angle scattering for estimating particle size distribution is to observe an ensemble, and then apply inversion using a kernel matrix based on Mie theory for spheres. The difference between properties of spheres and random shaped particles would alter the inversion due to a changed kernel matrix. For the present study, particles were separated by hydrodynamic size in a settling column into small size classes and the scattering properties were measured with a LISST-100 instrument.

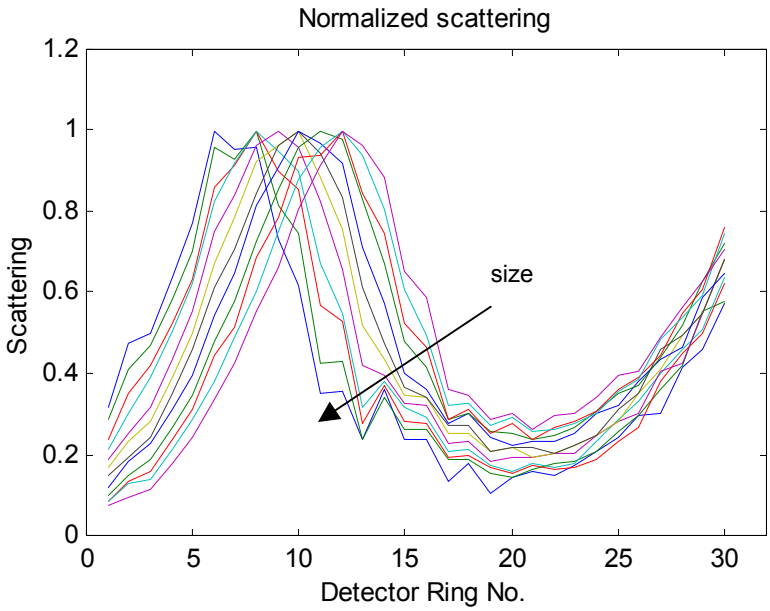

Figure 3: Multi-angle scattering properties of narrow-size natural particles. These shapes differ significantly from those for spheres (see Agrawal & Pottsmith, 2000; figure 2a). The implication is that field data my need to be revisited with this knowledge to recover improved size distributions.

Early results also suggest that these forms are stable across particles obtained from several different sources. If this is held true, it is likely that a *canonical* form for *natural particles* may be established.

IMPACT/APPLICATION

The work is still in the early stages to have made an impact.

TRANSITIONS

None.

RELATED PROJECTS

1 – **Dissipation Sensor:** In a program funded by NSF, we are examining the rate and kinematics of the dissipation variable in the lowest few centimeters of the bottom boundary layer. This region, the wave boundary layer, is the most critical in determining resuspension or settling of particles. Similar sediment sensors as in use in this program will also be employed, besides a laser dissipation rate sensor.

2 – **LISST-25:** In an unfunded separate program, a new optics principle was discovered that permits the use of two specially shaped detectors placed in the Fourier plane of a receiving lens, for observing the concentration and mean size of suspended particles. This new principle circumvents the difficulty of changing calibrations of prior transmissometers and optical scattering sensors. This program is internally funded from the Company's resources.

3 – **Small-Angle Scattering Properties of Natural Particles**:- Spurred by observations of differences in calibrations of sediment sensors for spheres vs. natural particles, we have completed the first phase of empirically characterization of the very small-angle scattering properties of these particles. Using a specially constructed stratified settling column, we have characterized the counterpart to Mie scattering properties for narrow size classes. This work is in preparation for publication.

REFERENCES

Agrawal, Y.C. and H.C. Pottsmith (2000). "Instruments for Particle Size and Settling Velocity Observations in Sediment Transport", Marine Geology, 168,(1-4), pp 89-114.

PUBLICATIONS

Dickey, T.D., Chang, G.C., Agrawal, Y.C., Williams, A.J. and P.S. Hill, 1998: Sediment resuspension in the wakes of Hurricanes Edourard and Hortense, Geophys. Res. Lett., v25,n18, pp 3533-3536.

Agrawal, Y.C., and H.C. Pottsmith, 2000: Instruments for Particle Size and Settling Velocity Observations in Sediment Transport, Marine Geology, **v**168/1-4, pp 89-114.

Agrawal, Y.C. and Traykovski, P., 2001: Particles in the bottom boundary layer, dynamics through events, Jour. Geophys. Res., v106, C5, pp 9533-9542.

Agrawal, Y.C., and H.C. Pottsmith, 2001: A new sensor for mean size and size-independent measurement of suspended sediment concentration (*in revision,* Marine Geology).

Agrawal, Y.C., and O. Mikkelsen: Small-angle scattering properties of natural particles, Applied Optics (to be submitted).

PATENTS

None**.**